TECHNICAL GUIDANCE DOCUMENT

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

ENGINEERING CONTROL: COVERS

Office of Land Quality

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Guidance Created: May 26, 2009
Guidance Updated: April 1, 2013

1.0 Purpose, Scope and Applicability:

This guidance provides basic design and operation & maintenance guidelines for surface cover structures over contaminated soil. Covers may be applied as an engineering control to control direct contact exposure to surface contamination and to prevent surface water infiltration and subsurface migration of contamination. Other exposure pathways, such as vapor intrusion, surface migration and storm water management are not addressed in detail. This guidance also does not intend to provide comprehensive instruction or direction on remedy selection, site-wide feasibility assessment, exposure, or risk assessment

This guidance is intended to apply primarily to hazardous substance or petroleum releases in the Remediation Services Branch (RSB) programs, and is not intended to be used at solid waste regulated units. Solid waste is defined in 329 IAC 10-2-174 and includes hazardous waste by definition. Applicability of this guidance shall be determined by each program, including the RCRA Corrective Action program.

2.0 Table of Contents:

3.0 Introduction:

In the past, various programs in the Office of Land Quality (OLQ) have used existing surfaces such as parking lots and concrete pads as part of the remedial decision process to address surface and subsurface exposure concerns. The materials and structure of these surfaces have varied depending on site conditions and characteristics. However, this variation between surface structures has been too broad to conform to any individual design standards. This guidance now classifies these variable structures used for closure as existing covers, and further defines a cover as a type of engineering control.

In the future, existing as well as new covers may be used. As section 4.0 explains, new covers typically require a complete replacement of the existing surface. Consequently, new covers have not been used often in the past since less costly repair of the existing surface has frequently provided adequate protection. In turn, this guidance does not intend to change how often a new or existing cover is used, but instead provides standard specifications[1] and guidelines to ensure long term structural integrity of covers.

This guidance is also provided to enhance the selection, construction, designs, operation[2], and maintenance concerns over the lifetime of the cover. Operation and maintenance guidelines provide measureable inspection criteria to ensure long-term care obligations.

4.0 Existing and New Cover Guidelines & Rationale:

4.1 Application Guidelines and Rationale:

This guidance classifies all covers into one of two groups, existing covers and new covers. The following guidelines and notes explain when and why an existing or new cover should be applied, and also explains typical construction considerations.

- New covers usually require much higher costs as well as complete demolition and re-construction of the existing surface. Most sites require only minor maintenance or a partial repair of the existing surface instead of a complete replacement.
- New cover designs should typically not be used for repairs, unless the existing surface is structurally equivalent to new design specifications in this guidance.
- Existing surface repair and maintenance of excavation holes, deterioration, or defects should either: (See Note)
    - Meet the original design specifications or objectives for the existing structure or
    - Follow recommended standard repair specifications below.[3]

[1] Specifications: materials, thicknesses, properties, test methods or other values listed in this guidance.
[2] The term "Operations" includes inspection by definition. "Inspection" is used where appropriate.
[3] Standard Repair Specifications: For Asphalt: Repairing Asphaltic Concrete Pavements http://www.pavementpro.org/asphaltspec.htm, and adding material specifications from INDOT Standard Specifications Section 401 and 408; For Concrete: INDOT Standard Specifications Sections 506 and 507. Note: INDOT updates for these standards should be used as they become available.

- The original slope and drainage design of the structure should remain intact to avoid puddles or standing water.
- For either new or existing covers, a drawing showing material layers with a material description should be submitted with the remediation plan (e.g., corrective action plan or remediation work plan)..

NOTE: Existing covers are typically designed for non-environmental purposes, such as withstanding vehicle, facilities, equipment, or storage loads. Since new cover designs in this document have an environmental purpose, existing surface repairs may not typically use new cover specifications. Using new cover specifications would create differential settlement, structural weaknesses, or other defects which would speed the deterioration or cracking of the surface. Typical examples of existing covers include asphalt pavement or gravel parking lots, concrete slabs and pads for industrial processing, concrete building floors, and lawns, grass fields or soil.

4.2 Design Considerations:

Critical considerations for the cover design include:

- The condition of the existing surface throughout the history of the impact (whether the surface has been well maintained or whether deterioration has been significant).
- Nature and extent of contamination, including chemicals of concern (COC) concentrations, COC properties (solubility mobility, etc), COC proximity to property boundary and other structures, depth to groundwater, COC vertical and horizontal locations.
- A comparison between soil and groundwater COC levels and closure levels. This includes past, present, and future levels, with estimates of post-remedial concentrations.
- Soil properties including permeability and soil type.
- How close the existing or proposed materials and thickness of the layers compare to standard specifications (Appendix 1).
- The age or weathering of the contamination, including groundwater levels and behavior as well as the migration potential of the plume: whether the plume is stable, migrating, shrinking, or unknown.
- Other issues, such as storm water management and vapor migration pathways as well as chemical compatibility between COCs and cover materials should be considered.

> Design Example: Assume the cover is cracked or heavily damaged and supplies large amounts of surface water into the contaminated subsurface near the property boundary, and also assume groundwater concentrations are increasing. Then the role of the cover might be to prevent infiltration and prevent off-site migration, and the cover may need major repair and re-surfacing.

5.0 Surfaces Application and Exposure Pathways:

This table matches surface materials with exposure pathways.
For new covers, the materials and thicknesses in the following table should be used at a minimum. The top layer materials should be constructed using a base layer as shown in the table and as explained in Section 6.0. As shown, the primary intent of a cover is direct contact prevention (denoted by a "P" in the table). If the base layer is clay, then the cover also provides a secondary level of infiltration protection (denoted by "S" in the table). If the base layer is only a fill material, such as sand, silt, or mixed materials, then the cover provides less, or no significant infiltration protection.

Existing covers also apply to the table, but may have varying materials and thicknesses, and consequently varying levels of protection.

Materials, Thicknesses and Exposure Pathways:

Materials	Pathway: Direct Contact	Pathway: Infiltration	Thickness	Comments Specifications
Top Layer				
Vegetation/ Topsoil	P	NO without base S with clay base	6 in Minimum	Vegetation required to prevent erosion
Asphalt	P	S	4 in. Minimum	For minimum infiltration use clay base, otherwise provides moderate protection
Concrete	P	S	5 in. Minimum	For minimum infiltration use clay base, otherwise provides moderate protection
Gravel Wood Chips	P	NO without base S with clay base	6 in. Gravel min. 3 in. wood chips or site spec.	Should use geotextile between gravel/chips & base.
Flexible Membrane Liner (FML) w/ layers	S	P	0.020 to 0.060 in.	Should also use sub-base, drainage, base, and top layers
Base Layer				
Clay Base	P	S	18 in. Minimum	Permeability 1E-06 cm/sec max.
Clean Fill Base	P	NO	18 in. Minimum	Soil: clay to sand Permeability: 10^{-3} cm/sec max.
P: Primary intent of control is to prevent exposure via this pathway. S: Secondary intent of control: Provides a significant reduction of exposure for this pathway in addition to the primary pathway. NO: No significant exposure protection for this pathway.				

Asphalt and concrete alone can provide a moderate degree of infiltration protection. Adding a clay base underneath these top layers increases the infiltration protection.

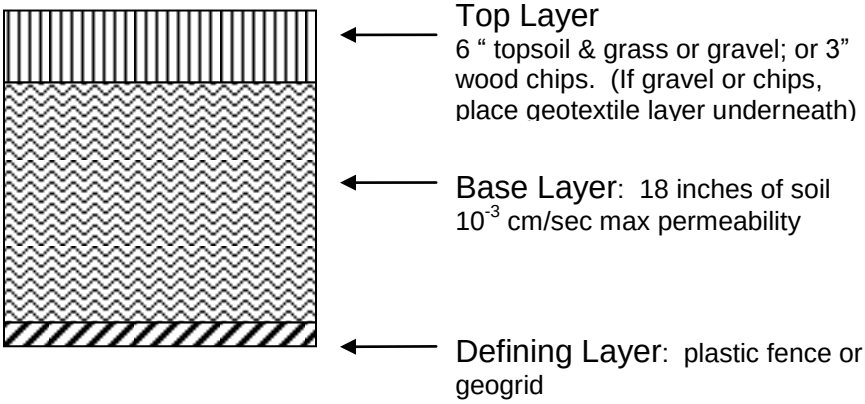
6.0 New Cover Designs:

This section includes new cover designs for direct contact and infiltration pathways. The direct contact design may also be used for infiltration prevention in some cases. New covers should adhere to these design specifications or similar specifications to insure a high level of quality in the new structure, to withstand long term operation, and to reduce long term maintenance costs. Design and construction specifications are summarized in tabular form in Appendix 1.

6.1 New Soil Cover Design:

For new cover construction, the cover design for preventing surface soil direct contact consists of three layers (top to bottom), a top layer, a base layer, and a defining layer as follows and as shown in Figure 1:

Figure 1: New Soil Cover
(Primarily for Direct Contact)



The top layer should be made of topsoil with grass covering the surface. The purpose of the top layer is to armor the cover surface to prevent significant erosion or structural deterioration. Selection of materials may be based on site usage.

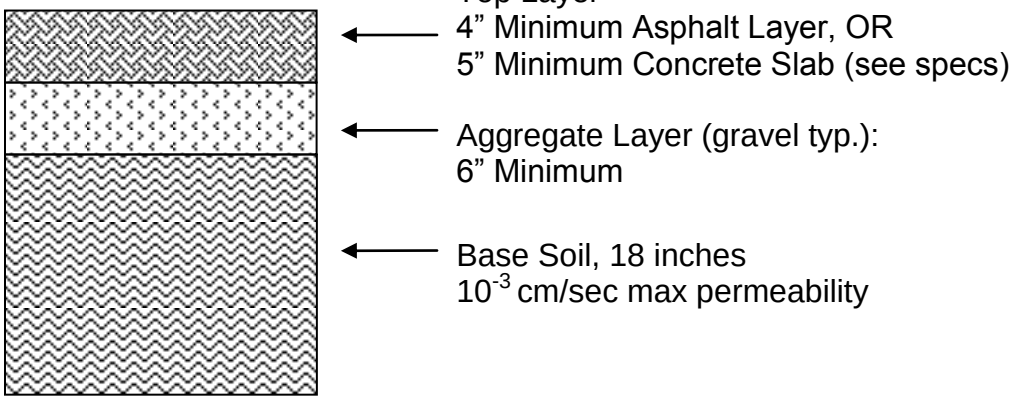
The base layer should be made of soil. The layer is intended to prevent contact with contaminated soil from routine surface activities.

The defining layer can be made of fence material or other type of non-degrading, porous sheeting material. For direct contact designs, the purpose of the layer is to visually mark or identify the contaminated area

The total thickness of the cover should be at least 24 inches. Additional specifications for design of these layers can be found in Appendix 1.

6.2 New Asphalt or Concrete Cover [4] Design : Asphalt or concrete covers are typically suitable for direct contact and may also be used for infiltration protection under appropriate conditions. From Figure 2, asphalt pavement and concrete structures are typically designed and constructed as follows, from top to bottom:
Top Layer, Aggregate Layer, and a Base Layer.

Figure 2: New Asphalt or Concrete Cover
(Primarily for Direct Contact)



The asphalt top layer should contain two lifts of asphalt with a minimum thickness of 2" per layer.

The concrete top layer should consist of a slab of 5" minimum thickness of unreinforced concrete, with a minimum compressive strength of 4000 psi.

The aggregate layer (typically gravel) should be a minimum of 6" thick. A geotextile fabric filter or similar material should be used between the aggregate layer and the base soil layer to prevent the aggregate from sinking into the base soil over time.

The base layer should be made of soil with the following specifications:

- Compacted in lifts of no more than 12 inches
- Maximum permeability of 1 x 10^{-3} cm/sec

[4] Design can also be guided by Indiana Department of Transportation (INDOT), Standard Specifications sections 207, 301, 302, 401, 402, and 502, 2008 (or as updated).

6.3 Optional Applications:

- Gravel, a stone blanket, or wood chips can be substituted in the top layer as long as the gravel/stones/chips are able to withstand worst-case surface water flow, and are also not allowed to significantly penetrate the base layer. Gravel should be at least 6 inches thick, however wood chip thickness is suggested at 3 inches, but may typically vary by site.
  - A geotextile fabric filter or similar material should be used between the top layer and the base soil layer to prevent the gravel/stone/chips from sinking into the base soil over time.

- The new soil and new asphalt/concrete cover designs can be used as an infiltration design if approved for closure. In this case, the maximum permeability for the base soil should be 1×10^{-6} cm/sec.

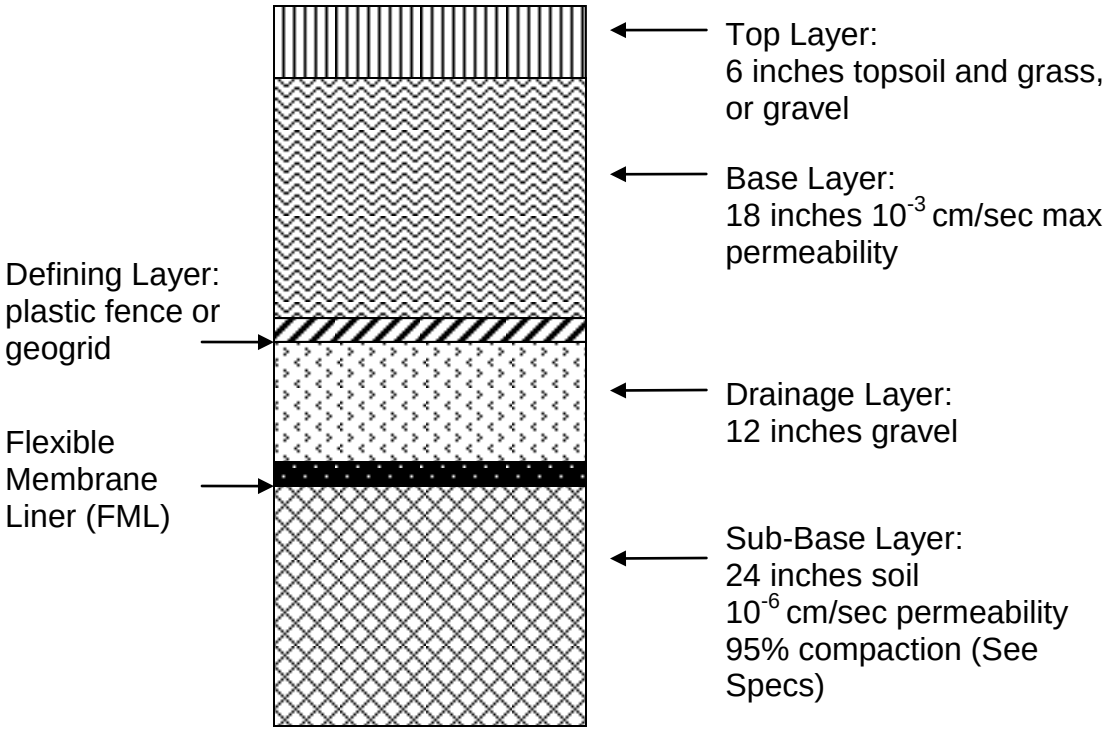
- Asphalt and Concrete are acceptable options for the top layer (See Figure 2). However, if either a vegetative cover or hard cover is acceptable for closure, the vegetative cover should be used instead of a hard cover due to lower maintenance costs and the tendency of hard covers to crack.

6.4 New Infiltration Prevention Cover Design (See Figure 3):

For new cover construction, the full scale cover design for preventing infiltration of water into contaminated soil or groundwater should include (top to bottom) all direct contact layers, a drainage layer, a flexible membrane liner, and a sub-base layer as shown in Figure 3 and as follows:

Figure 3: New Soil Cover

(Primarily for Infiltration)



The direct contact layers are identical to the direct contact design, except as noted where a fabric filter should be used as the defining layer to prevent base layer soil mixing and clogging of the drainage layer.

NOTE: A geosynthetic clay liner (GCL) can be used in the base layer as long as:

- No more than 12 inches of soil are replaced by the GCL, and
- The sub-base layer (below the GCL) is at least 24 inches thick.

The drainage layer drains water seeping through the base layer to prevent water from collecting and pooling, which can smear and erode the bottom of the base layer. This layer should be made of sand and/or gravel and should be 12" thick. A geosynthetic drainage matting, such as a geonet, can substitute for the sand/gravel drainage layer. Drainage layer outlets are needed to allow the drained water to seep out from under the cover.

The flexible membrane liner (FML) is typically 20-60 mil thick (mil = thousandths of an inch). The FML is the impermeable barrier which prevents water from penetrating into the contaminated soil, and in some cases may prevent high water table levels from penetrating above into the base layer. Examples include polyvinylchloride (PVC) and high density polyethylene (HDPE).

The sub-base layer provides a strong foundation to prevent uneven settlement and maintain the shape and structure of the cover. The base should be compacted to 95% of dry density and should have a smooth surface free of rocks/ sharp objects to protect the FML.

NOTE: Any soil layer more than 12 inches thick should be constructed in lifts of 8" to 12".

7.0 Additional Design Guidelines for All Covers

7.1 Cover Slopes:

The top surface of the cover should have a slope from 2% to 5%. Slopes apply to all layers as well. Note that direct contact covers also need to remove surface water to avoid pooling or accumulation which can erode or deteriorate the cover surface over time.

7.2 Cover Apron: The cover should extend at least 4 feet beyond the area of concern boundary. If the cover extends to a structure, then an appropriate interface should be constructed to meet design objectives.

7.3 Chemical Compatibility: The materials of the cover should be chemically compatible with the COCs. Compatibility includes not only direct contact between COCs and cover materials, but also COC vapors in high enough concentrations to kill vegetation or degrade the cover surface.

7.4 Utilities and Buildings:

Existing utility lines and piping may restrict the extent of the cover to avoid interruption of utility service. Conversely, buildings and other operations may have floors, surfaces, or foundations that act as a cover. Other structures such as surfaces supporting operating facilities (tanks, pumps, machines, etc.) may also act as a cover. The operation and maintenance plan should include inspection of all utility, building, and related areas acting as a cover.

7.5 As-Built Certification:

Once the cover is built, an "as-built" certification should be submitted showing that the materials and structure of the construction meet the proposed cover design. Note that these original specifications should already have been submitted (e.g., in a remediation work plan or feasibility assessment). The certification can be included as part of a closure certification document, or other appropriate submittal.

7.6 Design Modification:

A modification from a guideline specification should include a demonstration that the modified specification(s) is able to provide an adequate or equivalent level of protection. Typically, the larger the difference between the modification and the guideline, the more demonstration information needed. Demonstration methods include risk assessment, physical testing, technical references, or similar site applications.

8.0 Operation and Maintenance (O/M): **(See Appendix 2)**

This section and the Inspection and Maintenance (I/M) table provide more detailed criteria and guidelines of inspection and maintenance for cover management. As previously explained, enforceable documents such as environmental restrictive covenants (ERCs) provide the mechanism for tying together operation and maintenance (O/M) requirements to long term care obligations for a cover.

8.1 Maintenance Plan Submittal:

A plan for operation, maintenance, and monitoring should be submitted for review and approval for all sites using engineering controls, including covers. The plan may be submitted as part of a work plan (i.e., corrective action plan, remediation work plan) or as a stand-alone document. This plan or portions of this plan can be referenced in a statutory enforcement document (such as an ERC, agreed order, or permit) to serve as a primary mechanism for long term management of the cover. Appendix 2 provides an example O/M plan template and an I/M tracking form to assist planning.

Inspection and Maintenance Guidelines:

Materials	Design Life(Typ)	Inspection Frequency	Inspection Criteria	Maintenance Actions
All Covers	Cover Lifetime	As Scheduled (spring)	Pooling/ Puddles/ Discoloration	Fill depression/ Resurface / Regrade
			Erosion: Swales/ Gullies / Ripples	Fill depression/ Resurface / Regrade
Vegetation/ (Topsoil)	20 year	Semi-annual (spring)	Height of vegetation	Mowing: 2/year
			Bare Spots or lack of growth	Re-seed or change vegetation
			Wrong type (trees/crops bushes)	Remove / Compact / Resurface / Reseed
			Vectors (moles, termite mounds, nests)	Remove / Compact / Resurface / Reseed
Asphalt	10-15 year	Annual (spring)	Wide cracks (hand or shoe size), Alligator patterns	Seal cracks, add fill if needed
Concrete	20-30 year	Annual (spring)	Open Joints/Bad Sealant Wide Cracks	Replace sealant, grout or seal cracks, add fill
Gravel/Stone/ Wood Chips	15 year	Semi-annual (spring)	Gaps or sparse areas, depressions from settling	Add fill gravel/ stones/ or chips
Activity Restrictions				
On-site Construction	Cover Lifetime	As scheduled	Structure Overlap? Bldgs., landscaping, parking lots	Seal surface, Reconstruct or Relocate
Groundwater Wells	Cover Lifetime	As Scheduled	Present? Extraction, injection, monitoring wells	Seal Surface, Reconstruct or Relocate
Adjacent Operations	Cover Lifetime	As Scheduled	Impact? Nearby drainage /sewers, Foundations	Seal Surface, Reconstruct or Relocate

8.2 Operation Criteria and Maintenance Actions:

As previously mentioned, long term care obligations can often be met by repairing or replacing vehicular or landscaped surfaces. An example O/M plan, a table with inspection specifications and maintenance actions, and an inspection activity log are found in Appendix 2. The inspection log can be maintained on-site and should be available for OLQ inspection upon request. Operation/Inspection/Maintenance objectives are as follows:

All Covers: Inspection should take place in the spring after snow is gone to assess winter damage. Standing water or puddles can cause cover discoloration or bare spots and are indications that the slopes or surface of the cover are being damaged. Slopes should be reconstructed if the cover cannot adequately drain surface water.

Surface Swales/Gullies/Ripples or Mounding are signs of surface erosion, or uneven settlement. Surface erosion should be re-filled and re-graded if necessary. Uneven settlement may not need immediate attention if the surface is not cracked or broken, or if water is draining properly. However, uneven settlement may need more extensive repair in the future, including re-construction of the base soil. Such locations should be documented during inspection.

Cover lifetime: At the end of the typical design life the cover should be assessed, and any needed repair or replacement should be performed.

Vegetation:

- Mowing of the cover should be performed at least twice a year.
- Bare spots or lack of growth should be noted and areas should be re-seeded. If the type of vegetation appears to be ineffective, then a different type may be needed. Reseeding, soil additions, or reconstruction of the cover surface may be necessary.
- Non-remedy vegetation such as trees, food crops, or bushes should be identified and removed from the cover. These plants typically have deep roots which can penetrate the cover. Surface clearing of foreign vegetation, surface repairs, and reseeding should be done if needed.
- Vector damage such as mole holes, termite mounds, or animal nests should be noted and removed. Surface repairs and reseeding should be done if needed.

Asphalt Pavement: Wide cracks and alligator pattern cracks allow infiltration and possible direct contact. In addition, the underlying base layer can be damaged or eroded over time. Sealing cracks or filling and patching of openings with original material may be needed.

Concrete: Open joints or joints with no sealant as well as wide cracks allow infiltration and possible direct contact. In addition, the underlying base layer can be damaged or eroded over time. Joints should be sealed or grouted and cracks should be filled and patched with original material if needed.

Gravel, Stone Blanket, Wood Chips: Gaps or sparse areas resulting from settlement of underlying base soil can allow direct contact. Material should be added or adjusted to provide uniform thickness of the top layer. Also, surface runoff can sweep small gravel or wood chips away, leaving a washout trail. A larger size gravel or chip may be needed to prevent washout.

8.3 Activity Restrictions for On-site Operations / Adjacent Property:

On-site surface operations or construction which could damage or deteriorate the cover should be identified, assessed, and corrected where necessary. Plans or construction which overlaps the footprint of the cover should be identified in the inspection and addressed. Excavation or equipment penetration into the cover should be restricted, unless appropriate repairs or new structures are used to maintain closure objectives. Typical surface operations and activities include on-site roads and truck traffic, animal activity or grazing, parking lots, buildings, landscaping, constructions and demolitions which occur nearby or atop the cover.

> Example: Assume that during inspection a number of years after construction of the cover, groundwater wells, groundwater extraction equipment, injection wells, or monitoring wells are discovered on the cover surface. The ERC should be reviewed to see if groundwater wells are restricted from use. If use is allowed, the well should be inspected for proper surface seal construction to insure the integrity of the cover and prevent direct contact or infiltration.

Adjacent property or nearby areas having operations or activity which could affect sub-cover groundwater flow should be identified. Even if direct contact is the only pathway of concern at closure, changes to groundwater behavior can affect contamination. For instance, elevated groundwater can reach contaminated soil and initiate migration, or a steeper gradient can also enhance migration. A review of available groundwater monitoring data near the cover should also be included in the inspection. Examples include underground drinking water extraction, waste or wastewater disposal, and process water injection, subsurface sewer or drainage structures.

Maintenance actions may not always be necessary after inspection. However, future actions such as restricting access, repairing, re-designing or constructing, or relocating the facility or operations may be needed.

9.0 References:

ASTM International, Standard Guide for Application of Engineering Controls to Facilitate Use or Redevelopment of Chemical-Affected Properties, ASTM International, E 2435-05, July 2005. Also, ASTM Standards: E 2091-05, D-2922, D-5084 .

AASHTO TP 64-03, "Standard Method of Test for Prediction of Chloride Penetration in Hydraulic Cement Concrete by the Rapid Migration Procedure," American Association of State Highway and Transportation Officials, Washington, DC, 2003.

Indiana Administrative Code, Article 10, Solid Waste Land Disposal Facilities, 329 IAC 10-2-174, 2008.

Indiana Department of Environmental Management, "Remediation Closure Guide", Non Rule Policy Document #0046-R1, http://www.in.gov/idem/6683.htm, March 22, 2012.

Indiana Department of Transportation (INDOT), Standard Specifications sections 207, 301, 302, 401, 402, 408, 502, 506, and 507, 2008.

Massachusetts Department of Environmental Protection, "Guidance on the Use, Design, Construction, and Monitoring of Engineered Barriers," Public Comment Draft, Bureau of Waste Site Cleanup, Boston, MA, Nov. 2002.

New York State DEC, Brownfield Cleanup Program Summary, NYS DEC, 2008 Current Website: http://www.dec.ny.gov/chemical/8648.html.

Repairing Asphaltic Concrete Pavements; The National Pavement Contractors Association; August 4, 2000. http://www.pavementpro.org/asphaltspec.htm

USEPA, Operation and Maintenance in the Superfund Program, OSWER 9200.1-37FS EPA 540-F-01-004, May 2001.

USEPA, Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills, OSWER, (5306W), EPA530-F-97-001, Revised December 2001.

US Army Corps of Engineers, CECW: Checklist for Hazardous Waste Landfill Cover Design: TL 1110-1-162: 06830 Sep 01.

Wisconsin DNR, Guidance on Soil Performance Standards, Wisconsin DNR PUB-RR-528, April, 2004.

Wisconsin DRN, Guidance for Cover Systems as Soil Performance Standard Remedies, Wisconsin DNR PUB-RR-709, January, 2007.

Appendix 1: Design Specifications

The specifications in the table are the same specifications found in the design sections, with test methods and frequencies added. Specifications can be used for either new or existing covers. Specification guidelines should be followed to insure a high level of quality in the new structure, to withstand long term operation, and to reduce long term maintenance costs. As mentioned in Section 6, other materials and specifications may be appropriate for site conditions. Hence, modifications can be proposed and compared to these specifications to assist OLQ approval of the modification.

STANDARD SPECIFICATIONS

Standard Direct Contact and Infiltration Design				
Layer / Material	**Test Function**	**Test**	**Specification**	**Frequency**
Base Layer Soil	Compaction	ASTM D 2922	95% of dry density	1/1000 cy
Base Layer Soil: Direct Contact Design	Permeability	ASTM D 5084	$1x10^{-5}$ cm/sec	1/1000 cy
Base Layer Soil: Infiltration Design	Permeability	ASTM D 5084	$1x10^{-6}$ cm/sec	1/1000 cy
Base Layer:	Thickness		8 - 12 inch lifts	
Aggregate: Gravel	Drainage		#53 stone	
Asphalt:	Thickness		4 inches, 2 lifts	
Concrete:	Thickness		5 inches	
Asphalt: Infiltration	Permeability	ASTM D 5084	$1x10^{-7}$ cm/sec	
Concrete: Infiltration: Portland Cement	Rapid Migration	AASHTO TP64	$1x10^{-7}$ cm/sec	
Top Slopes	Drainage		2 – 5%	
Cover Apron	Extension beyond contamination boundary		4 feet beyond all edges	
Flexible membrane liner (FML) / high density polyethylene (HDPE)	Thickness		60 mil	Per roll
Sub-base Layer	Compaction	ASTM D-2922	95% of dry density	1/1000 cy
Sub-base Layer	Permeability	ASTM D 5084	$1x10^{-6}$ cm/sec	1/1000 cy

Appendix 2:

EXAMPLE COVER OPERATION AND MAINTENANCE PLAN

[DATE]

Property Located at:

[ACTIVITY ADDRESS]

[City, County]

[IDEM Program Area and Program ID]

Introduction

Instructions: This document is an example 'Operation and Maintenance Plan' for a cover at the above-referenced property. Edit the template appropriately in the bracketed areas.

This Operation and Maintenance Plan has been prepared by [*insert name of preparer*] for the cover remedy installed at the above-referenced site. It outlines the policies and procedures for the long-term maintenance and monitoring of the existing cover occupying the area over the [soil] [and] [contaminated groundwater plume] on-site. The contaminated [soil] [and/or] [groundwater plume] is impacted by [enter list of contaminant(s)]. The location of the [*insert type of cover* (paved surface, building, etc.)] to be maintained in accordance with this plan, as well as the impacted [soil] [and] [groundwater plume] are identified in the attached map.

Cover Purpose

The surface over the contaminated [soil] [groundwater plume] serves as a barrier to [prevent direct contact with residual soil contamination that might otherwise pose a threat to human health] [retard or prevent infiltration to minimize future soil-to-groundwater contamination migration]. Based on the current and future use of the property, the cover should serve these functions unless disturbed or is deteriorated.

Inspection Activities

The [*insert type of cover*] overlying the contaminated [soil] [groundwater plume] and as depicted in the map may be inspected [*insert proposed time frame*[5] (annually, semi-annually, quarterly, etc.)] [in the months of [April or May[6]] [insert other timeframe]]. The inspections may be performed to ensure that the cover remains intact, and to evaluate damage due to settling, exposure to the weather, wear from traffic, increasing age and other factors that can cause [additional infiltration into] [or exposure to] underlying soils.

[5] Vegetative covers should be inspected at least quarterly for the first year after construction; vegetative, soil, or gravel covers should include provision for inspection after severe storms

[6] The timeframe for annual inspections should be in the spring, after snow and ice is gone, to assess freeze/thaw damage.

Any area where soils have become or are likely to become exposed may be documented. A log of the inspections and any repairs should be maintained by the property owner. The log may include recommendations for necessary repair of any areas, including areas where underlying soils are exposed. Once repairs are completed, they may be documented in the inspection log. The inspection log should be kept on site and made immediately available for review by the IDEM Office of Land Quality (OLQ), its successor, and/or other appropriate state agency.

Maintenance Activities

If problems are noted during the annual inspections or at any other time during the year, repairs may be scheduled as soon as practical. Repairs can include patching and filling operations or they can include larger resurfacing or construction operations. In the event that necessary maintenance activities expose the underlying soil, the owner should inform maintenance workers of the direct contact exposure hazard and provide them with appropriate personal protection equipment ("PPE"). The owner should also sample any soil that is excavated from the site prior to disposal to ascertain if contamination remains. The soil should be treated, stored and disposed of by the owner in accordance with applicable local, state and federal law.

In the event the paved surfaces and/or the building overlying the [soil] [and/or] [contaminated groundwater plume] are removed or replaced, the replacement cover should meet original design specifications, including permeability. Any repair or newly constructed cover may be subject to the same maintenance and inspection guidelines as outlined in this Maintenance Plan unless indicated otherwise by the OLQ or its successor.

The property owner, in order to maintain the integrity of the [*insert type of cover*], may maintain a copy of this Maintenance Plan on-site and make it available to all interested parties (i.e. on-site employees, contractors, future property owners, etc.) for viewing.

Amendment or Withdrawal of Maintenance Plan

This Maintenance Plan can be amended or withdrawn by the property owner and its successors with the written approval of the IDEM Office of Land Quality.

Contact information for person/persons responsible for implementing this plan.

[NAME]
[ADDRESS]
[PHONE #]

Site Owner and Operator:

[NAME]
[ADDRESS]
[PHONE #]

OLQ: [OLQ Program Area]
[ADDRESS]
[PHONE #]

Inspection / Maintenance Activity Log: The following table should be used to track and monitor maintenance activity to insure that remedial objectives continue to be met in the future. This table can be included in the proposed remedial action plan (or equivalent document).

Inspection Date	Inspector	Inspection Criteria	Maintenance Action Needed	Previous Maintenance Completed?

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To make a one-page Quick Reference (double-sided)

Appendix 3: QUICK REFERENCE

This summary page can be used to quickly guide or check design and operation & maintenance proposals. See individual sections for details.

- The Materials/Thicknesses/Exposure Pathways table is for existing or new covers.
- Figures 1 and 2 are for new cover designs only. Most sites may only need a direct contact design. Existing covers should not use new cover designs for repair unless both structures are equivalent. New covers typically require complete demolition of existing cover and are significantly more expensive than an existing cover.
- The Inspection & Maintenance Criteria table can be used to guide the O/M Plan submittal. The O/M plan can be used to manage the cover section of an ERC.

Materials, Thicknesses and Exposure Pathways (Section 6.0)

Materials	Pathway: Direct Contact	Pathway: Infiltration	Thickness	Comments Specifications
Top Layer				
Vegetation/ Topsoil	P	NO without base S with clay base	6 in Minimum	Vegetation required to prevent erosion
Asphalt	P	S	4 in. Minimum	For minimum infiltration use clay base, otherwise provides moderate protection
Concrete	P	S	5 in. Minimum	For minimum infiltration use clay base, otherwise provides moderate protection
Gravel Wood Chips	P	NO without base S with clay base	6 in. Gravel min. 3 in. wood chips or site spec.	Should use geotextile between gravel/chips & base.
Flexible Membrane Liner (FML) w/ layers	S	P	0.020 to 0.060 in.	Should use sub-base, drainage, base, and top layers
Base Layer				
Clay Base	P	S	18 in. Minimum	Permeability 1E-06 cm/sec max.
Clean Fill Base	P	NO	18 in. Minimum	Soil: clay to sand Permeability: 10^{-3} cm/sec max.

P: Primary intent of control is to prevent exposure via this pathway.
S: Secondary intent of control: Provides a significant reduction of exposure for this pathway in addition to the primary pathway.
NO: No significant exposure protection for this pathway.

Figure 1: New Soil Cover
(Primarily for Direct Contact) (Section 6.0)

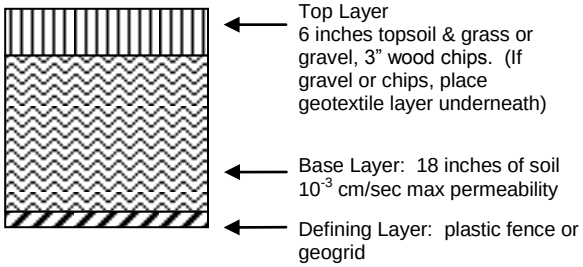
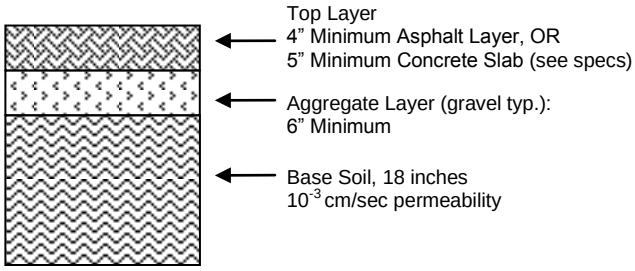


Figure 2: New Concrete or Asphalt Cover
(Primarily for Direct Contact) (Section 6.0)



NOTE: Top slopes 2 – 5 % (Vert/Horiz**)**

Inspection & Maintenance Criteria (Section 8.0)

Materials	Design Life(Typ)	Inspection Frequency	Inspection Criteria	Maintenance Actions
All Covers	Cover Lifetime	As Scheduled (spring)	Pooling/ Puddling/ Discoloration	Fill depression/ Resurface / Regrade
			Erosion: Swales/ Gullies / Ripples	Fill depression/ Resurface / Regrade
Vegetation/ (Topsoil)	20 year	Semi-annual (spring)	Height of vegetation	Mowing: 2/year
			Bare Spots or lack of growth	Re-seed or change vegetation
			Wrong type (trees/crops bushes)	Remove / Compact / Resurface / Reseed
			Vectors (moles, termite mounds, nests)	Remove / Compact / Resurface / Reseed
Asphalt	10-15 year	Annual (spring)	Wide cracks (hand or shoe size), Alligator patterns	Seal cracks, add fill if needed
Concrete	20-30 year	Annual (spring)	Open Joints/Bad Sealant Wide Cracks	Replace sealant, grout or seal cracks, add fill
Gravel/Stones /Wood Chips	15 year	Semi-annual (spring)	Gaps or sparse areas, depressions from settling	Add fill gravel, stones, or wood chips
Activity Restrictions				
On-site Construction	Cover Lifetime	As scheduled	Structure Overlap? Bldgs., landscaping, parking lots	Seal surface, Reconstruct or Relocate
Groundwater Wells	Cover Lifetime	As Scheduled	Present? Extraction, injection, monitoring wells	Seal Surface, Reconstruct or Relocate
Adjacent Operations	Cover Lifetime	As Scheduled	Impact? Nearby drainage /sewers, Foundations	Seal Surface, Reconstruct or Relocate